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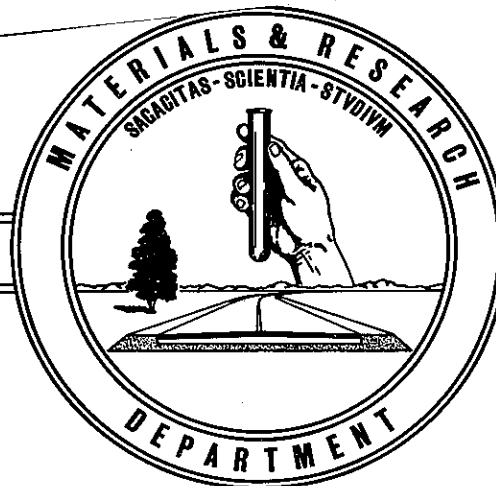
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STATE OF CALIFORNIA
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A SURVEY OF EARTH-BORNE VIBRATIONS
AT PARKSIDE MEDICAL - DENTAL BUILDING

67-61



OCTOBER 1967

State of California
Highway Transportation Agency
Department of Public Works
Division of Highways
Materials and Research Department

October 1967

Project W. O. 36418

Mr. Alan S. Hart
District Engineer
District 04
Division of Highways
San Francisco, California

Dear Sir:

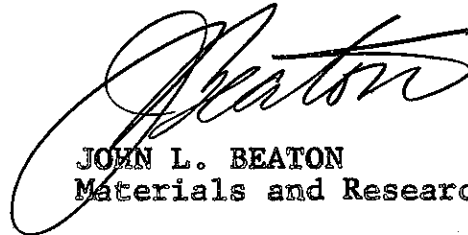
Submitted for your consideration is a report
entitled:

A SURVEY OF EARTH-BORNE VIBRATIONS
AT PARKSIDE MEDICAL-DENTAL BUILDING

ERIC F. NORDLIN
PRINCIPAL INVESTIGATOR

J. E. BARTON and W. CHOW
CO-INVESTIGATORS

Very truly yours,



JOHN L. BEATON
Materials and Research Engineer

WC/JEB:mw
Attach.

I. INTRODUCTION

In response to Mr. Ayanian's August 17th telephone call to Mr. Beaton, the laboratory on August 22, 1967, conducted a vibration survey at the Parkside Medical-Dental Building, Figures 1 and 2, located at 1885 Norfolk Street, San Mateo, California.

Mr. Grant, the owner of the medical-dental building, had expressed his concern that the fill haul trucks crossing Bridge No. 35-193 are causing a vibration problem in his building. Bridge No. 35-193 is not yet open to public traffic as of August 1967. The fill haul trucks are the contractor's equipment for constructing Road 04-SM-92-12.2/14.3X, Contract No. 04-134644.

II. CONCLUSIONS

1. Fill haul trucks crossing the bridge are shaking Parkside Medical-Dental Building.
2. The building floor vibrates like a sprung dance floor. Foot traffic on Dr. Holtzman's Room 4 created floor vibrations almost as large as the floor vibrations created by trucks crossing the bridge.
3. The bay mud ground upon which the building is built is unstable. Earth-borne vibrations are not attenuated but emanate for quite a distance and over a large area.
4. The natural frequency of the building floor and the ground is identical so that ground vibrations "couple" directly into the floor and set it into resonance.
5. Conclusions 2, 3, and 4 indicate that a probable vibration problem existed in the building prior to the erection of the bridge. The bridge has accentuated the building vibration problem but is not the primary cause.

III. TEST PROCEDURE

The test procedure consisted of recording traffic induced earth-borne vibrations inside of the medical-dental building; outside of the medical-dental building; on the bridge deck; in the general area of the building; and also inside building vibrations not caused by bridge truck traffic.

Vibration measurements during a test run were recorded simultaneously with two seismometers and their associated equipment shown in Figure 3.

IV. DISCUSSION

Bridge 35-193 in the City of San Mateo has recently been completed (July 1967) and will be a portion of road 04-SM-92. This bridge is not yet open to public traffic; however, the contractor routes his fill haul trucks across it in the construction of road 04-SM-92-12.2/14.3X, Contract No. 04-134644. This bridge was built within 13 feet of the Parkside Medical-Dental Building as shown in Figures 1 and 2. Mr. Grant, owner of the building, has expressed his concern that fill haul trucks crossing the bridge are shaking his building. His major concern was that the doctors' rooms - Locations 1, 2, 3, and 4 in Figure 1 - facing the bridge were particularly susceptible to vibrations emanating from the bridge.

On August 22, 1967, Mr. Raggio, District 04 attorney, and the laboratory crew in the company of Mr. Grant discussed and surveyed the building with respect to bridge earth-borne vibrations affecting his building.

To determine the bridge deck vibrations and the amount transmitted into the medical building, one of the two seismometers was placed on the bridge deck as shown in Figure 1, Location 5. A photograph of this seismometer is shown in Figure 4. This seismometer recorded the vibrations on the bridge deck due to truck passages. The second seismometer was successively moved from one doctor's room to another, while the bridge seismometer remained fixed. The two seismometers simultaneously and respectively recorded bridge deck vibrations and room vibrations during a truck passage on the bridge. Figure 2, previously mentioned, is a plan site of the various test locations.

Figure 5 is a view of the second seismometer in Dr. Covey's Room 1 while Figure 6 is the record of the vibrations recorded in this room and on the bridge deck during a passage of a loaded fill haul truck crossing the bridge. This record indicates that Dr. Covey's Room 1 vibrated 5 milli-inches at 2.5 cps (cycles per second) while the bridge deck vibrated 2 milli-inches at 2.5 cps during this truck crossing of the bridge. Several truck passage recordings were made with the seismometer in Room 1; however, only the largest vibrations recorded are reported herein and similarly for the other locations throughout this report.

The second seismometer was then moved from Dr. Covey's Room 1, successively, to Dr. Covey's Room 2, Room 3, and then to Dr. Holtzman's Room 4 while the bridge seismometer remained in the same location. Figures 7 and 8 show the second seismometer in Rooms 3 and 4. The vibration records for Rooms 2, 3,

and 4 are shown in Figures 9, 10, and 11. Of the four doctors' rooms monitored, Dr. Holtzman's Room 4 vibrated the most at 8 milli-inches and 3 cps as shown in the recording of Figure 11. This appears reasonable since his room is the closest to the bridge being 13 feet from it as shown in Figure 1.

It was of interest to determine the amount of vibration in the building and on the bridge deck when no trucks were crossing the bridge. A recording was made of this condition in Dr. Holtzman's Room 4 and shown in Figure 12. This figure shows that the bridge was vibration free but that Room 4 had a background vibration of 0.2 milli-inches.

Mr. Grant had also expressed his concern that his office areas, Locations 7, 8, and 9 in Figure 1, were also susceptible to vibrations emanating from the bridge. Therefore a vibration survey was also conducted in that portion of his building in a similar fashion previously explained. The only difference was that the bridge deck vibrations were not monitored. The bridge deck seismometer was moved to Location 6, Figure 1, 5 feet from the building. It was of interest to record the amount of vibrations alongside of the building due to vibrations emanating from the bridge while simultaneously recording building vibrations. The results are shown in Figures 13, 14, and 15 and are self-explanatory. The largest vibration, 4.0 milli-inches at 2.7 cps, was recorded in Mr. Grant's conference room as shown in Figure 15.

During the interval when no trucks were crossing the bridge, a recording was made of the "quiet" or background vibrations in Grant's secretarial office and simultaneously at Location 6 outside of the building. This recording is shown in Figure 16 and shows the office floor and the ground outside of the building is in a continuous state of vibration although not subjectively perceptible.

These vibrations were 0.5 milli-inches for the office floor and 0.8 milli-inches for the ground. This is in contrast to the bridge quiescent period (no trucks crossing it) when no vibrations were recordable as shown in Figure 11.

To compare the results from a previous vibration study, the laboratory in June 1967 had measured 0.44 milli-inches of vibration on the ground directly beneath the Prairie Street undercrossing structure of the San Diego Freeway. This ground vibration was created by a controlled test truck traveling across the structure at 45 mph. This vibration level, 0.44 milli-inches, is typical and average of many ground-structure vibrations recorded by the laboratory throughout the state. In comparison the medical-dental building quiescent ground vibrations of 0.8 milli-inches is almost twice as large as that on the ground beneath the Prairie Street structure. The secretarial's quiescent floor vibrations of

0.5 milli-inches is slightly more than that on the ground beneath the Prairie Street structure.

This comparison shows that the building floor is shaky and the building is built on shaky ground. The background vibrations of the building floor and ground are more than that created by a truck passage across a freeway structure.

During the course of this investigation, the laboratory crew noted that the floor vibrated perceptibly from foot traffic. Therefore, floor vibrations from foot traffic were recorded in Dr. Covey's Room 2, Dr. Holtzman's Room 4, Grant's secretarial office (Location 8), and in Grant's office (Location 7). These recordings are shown in Figures 17, 18, 19, and 20, and are self-explanatory. It is significant to note that Dr. Holtzman's Room 4, Figure 18, had the largest "walking vibrations", 6.3 milli-inches, and also the largest vibrations, 8.0 milli-inches, from truck traffic on the bridge. This series of "walking vibration" recordings was made when there was no truck traffic on the bridge.

It was of interest to determine the vibration characteristic of the ground in the general area of the building. Ground vibrations generated by passing trucks on 19th Avenue were measured at Locations 10, 11, 12, and 13 as shown in Figure 1. The reading at Location 10 was taken simultaneously with the reading at Location 11. Readings at Locations 12 and 13 were also simultaneously taken. These measurements away from the building and the bridge show the high vibration conductivity of the ground in the general area. These vibration results are shown in Figures 21 and 22. Note that the largest vibration, 6.6 milli-inches, Figure 21, was at Location 11 which was 17 feet from the truck path and more than 150 feet away from the building.

Figure 22 is a vibration record of car traffic in Norfolk Street. Note that vibrations are too small emanating from car traffic to be recordable.

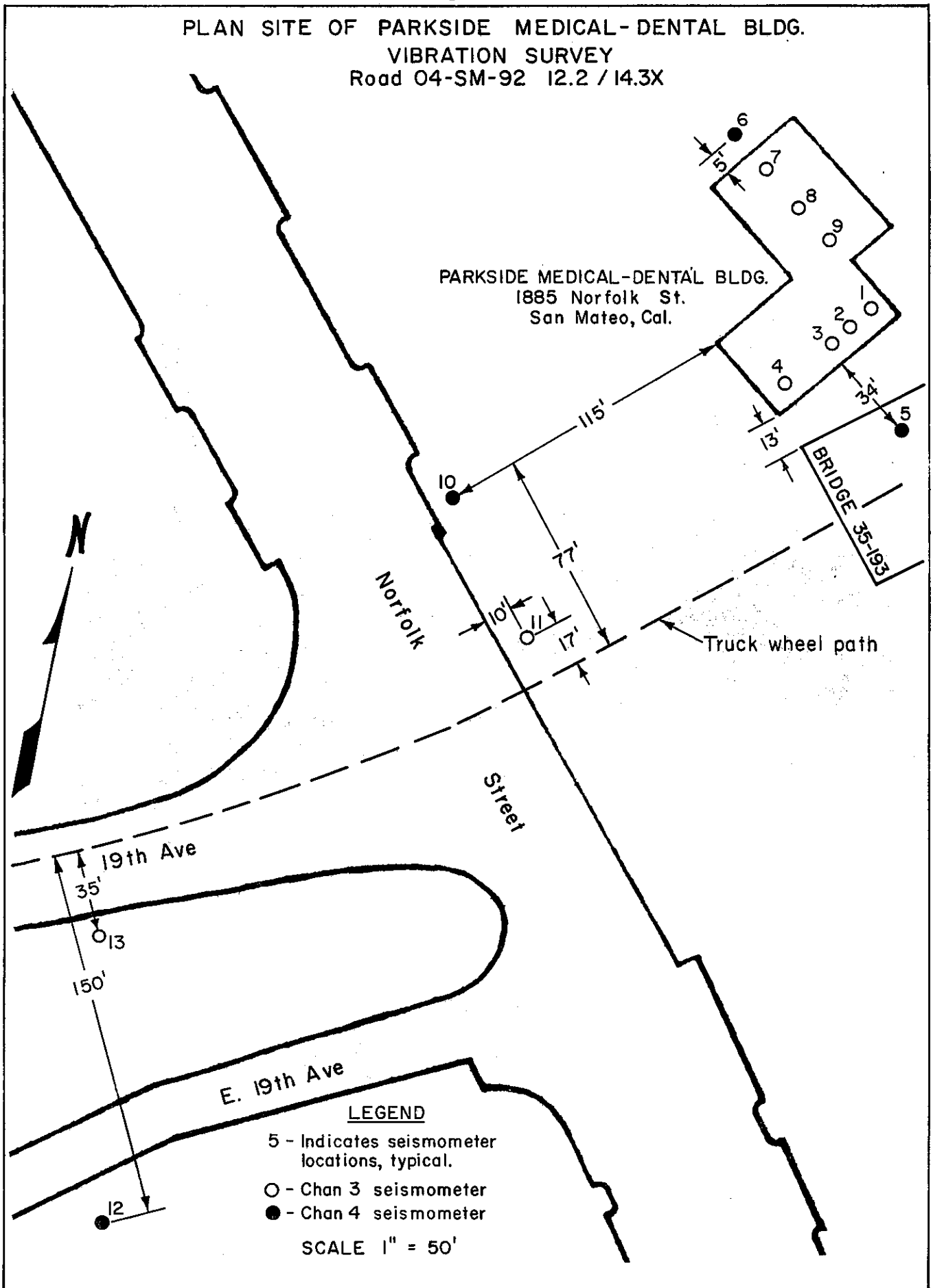
V. SUMMARY

Figure 24 is a bar graph summary of the vibrations discussed in the previous pages. There is no doubt that trucks crossing the bridge are shaking the medical-dental building. The results are clearly shown in Figure 24. However, there are other contributing causes.

1. The building floor is like a sprung dance floor. The laboratory crew could definitely feel the floor vibrate as people walked around. The "walking vibrations" of 6.3 milli-inches recorded in Dr. Holtzman's Room 4 is, in many cases, more than that caused by truck traffic on the bridge. Figure 24 indicates that only Location 3 (7 milli-inches) and Location 4 (8 milli-inches) had truck induced vibrations larger than the 6.3 milli-inches of "walking vibrations". Also note that the "walking vibrations" in Grant's secretarial office and his office, 4.6 milli-inches, were larger than the vibrations on the bridge deck (1.2 to 2.0 milli-inches) due to truck traffic.
2. The bay mud ground in this area is inherently unstable so that vibrations are not attenuated but emanate for quite a distance and over a large area. This is evidenced by the vibrations measured at Locations 6, 10, 11, 12, and 13. In other words, truck traffic on the bridge structure is not the basic cause of ground vibrations. The unstable ground is its own source of vibration.
3. The natural frequency of the building floor and the ground is identical, i.e., 2 - 3 cycles per second. Any ground vibration will "couple" directly into the building floor and set the floor into resonance. This is evidenced by the large floor vibrations as opposed to the smaller exciting source vibrations, i.e., bridge deck vibrations.

The above three causes indicate that a probable vibration problem existed in the building prior to the erection of Bridge No. 35-193. It is felt that only a part of the building vibration problem can be attributed to the bridge structure.

Figure 1



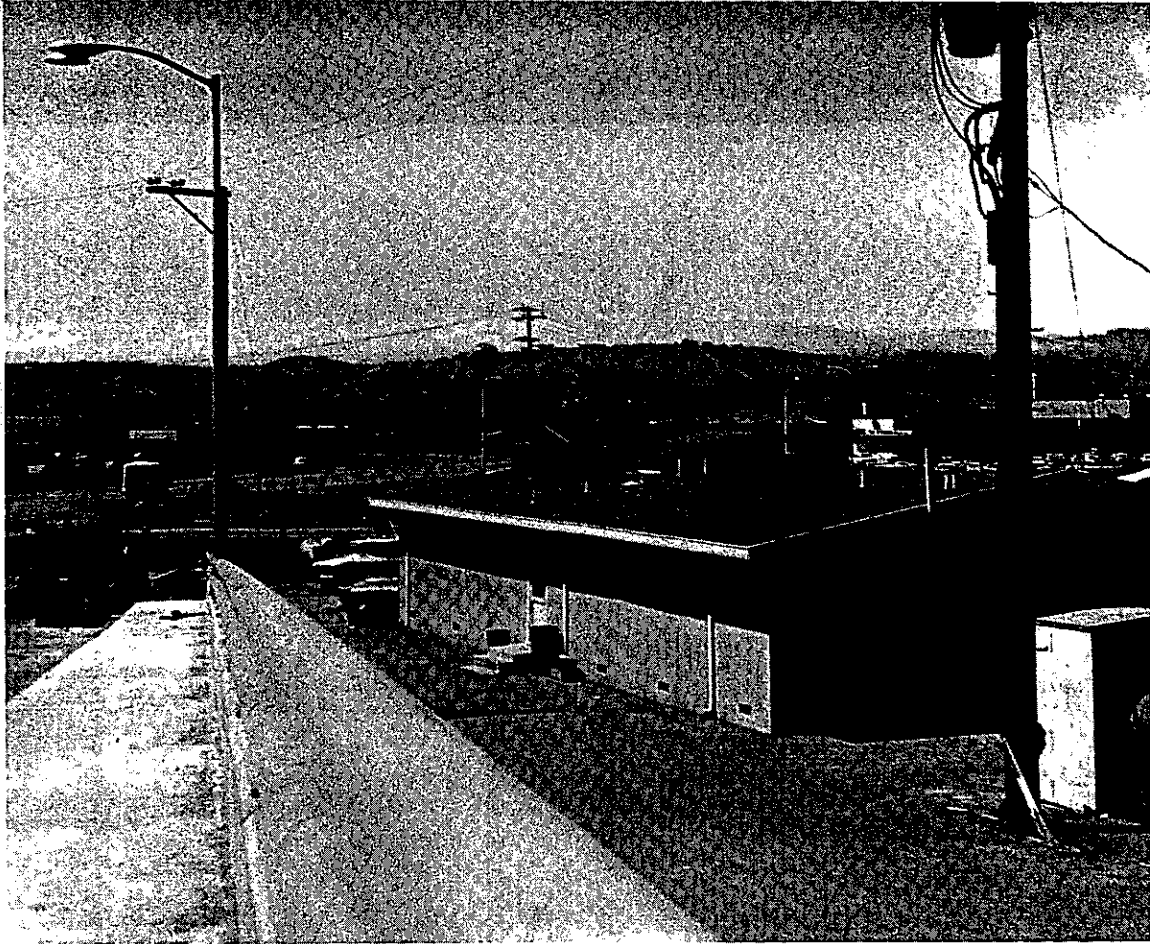
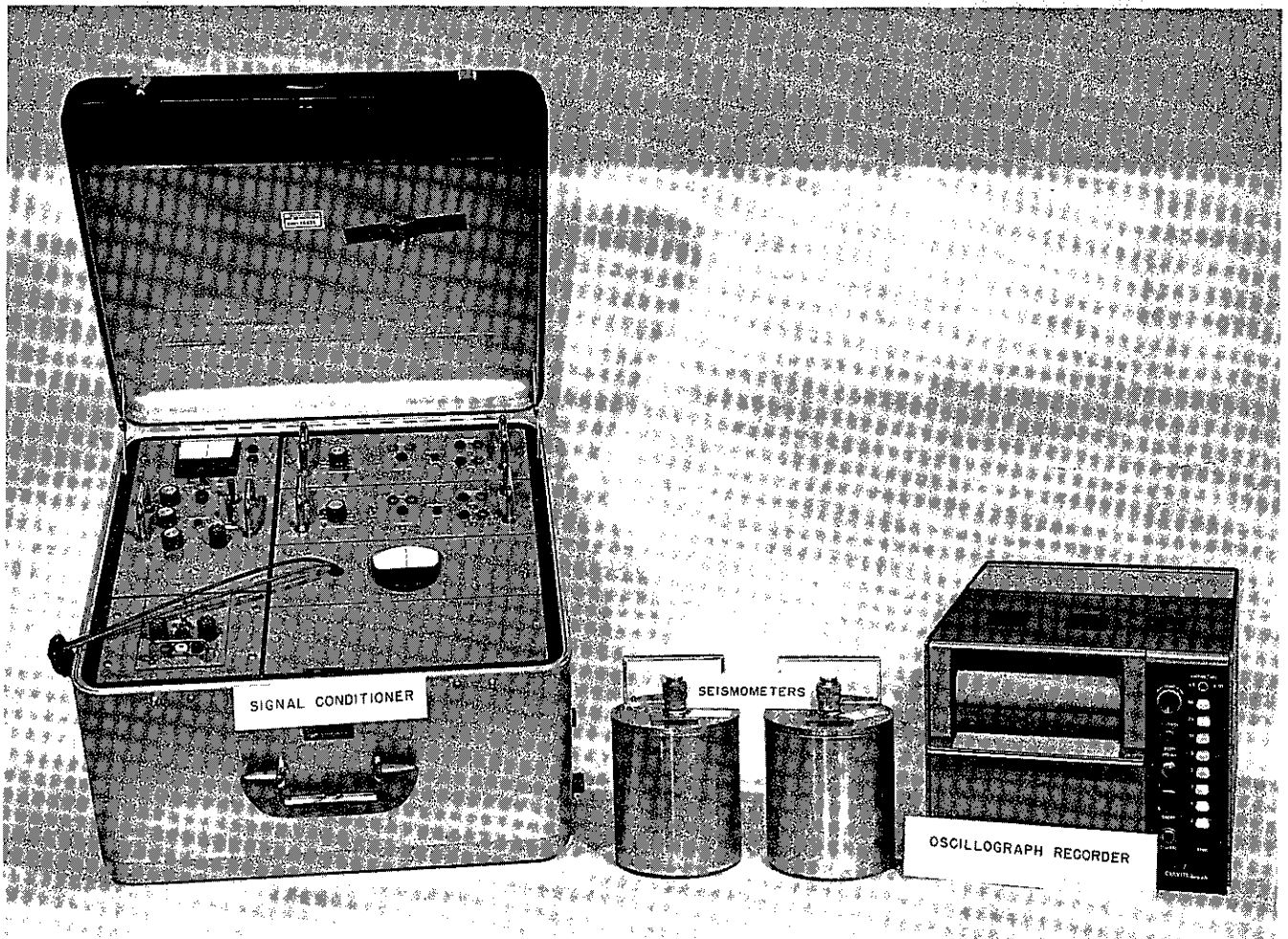


FIGURE 2

**View of bridge curb-railing and
Parkside Medical-Dental Building**



EARTH-BORNE VIBRATIONS
MEASURING EQUIPMENT

FIGURE 3

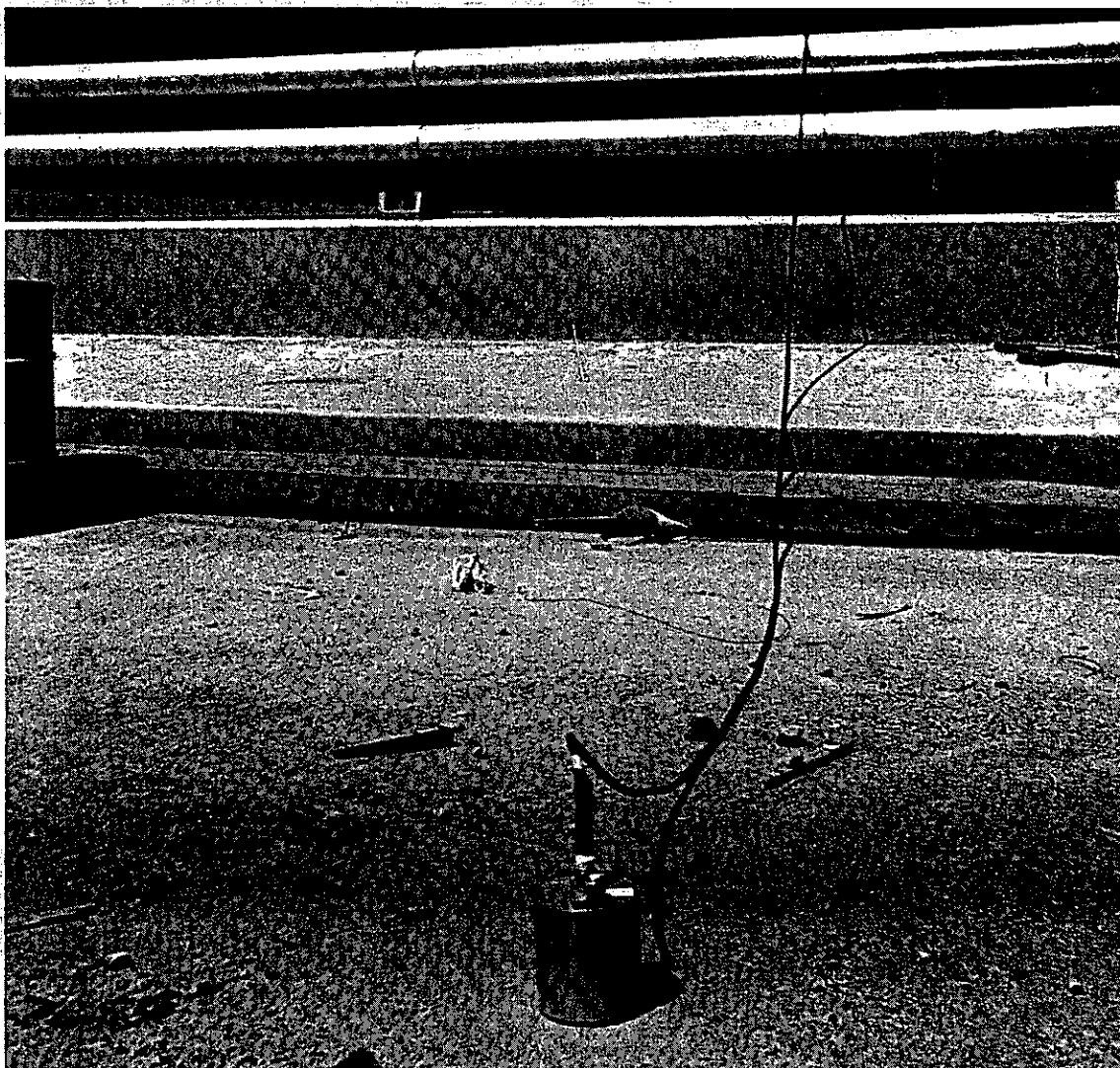


FIGURE 4

Seismometer on bridge deck. See
Location 5 in Figure 1 Plan Site.

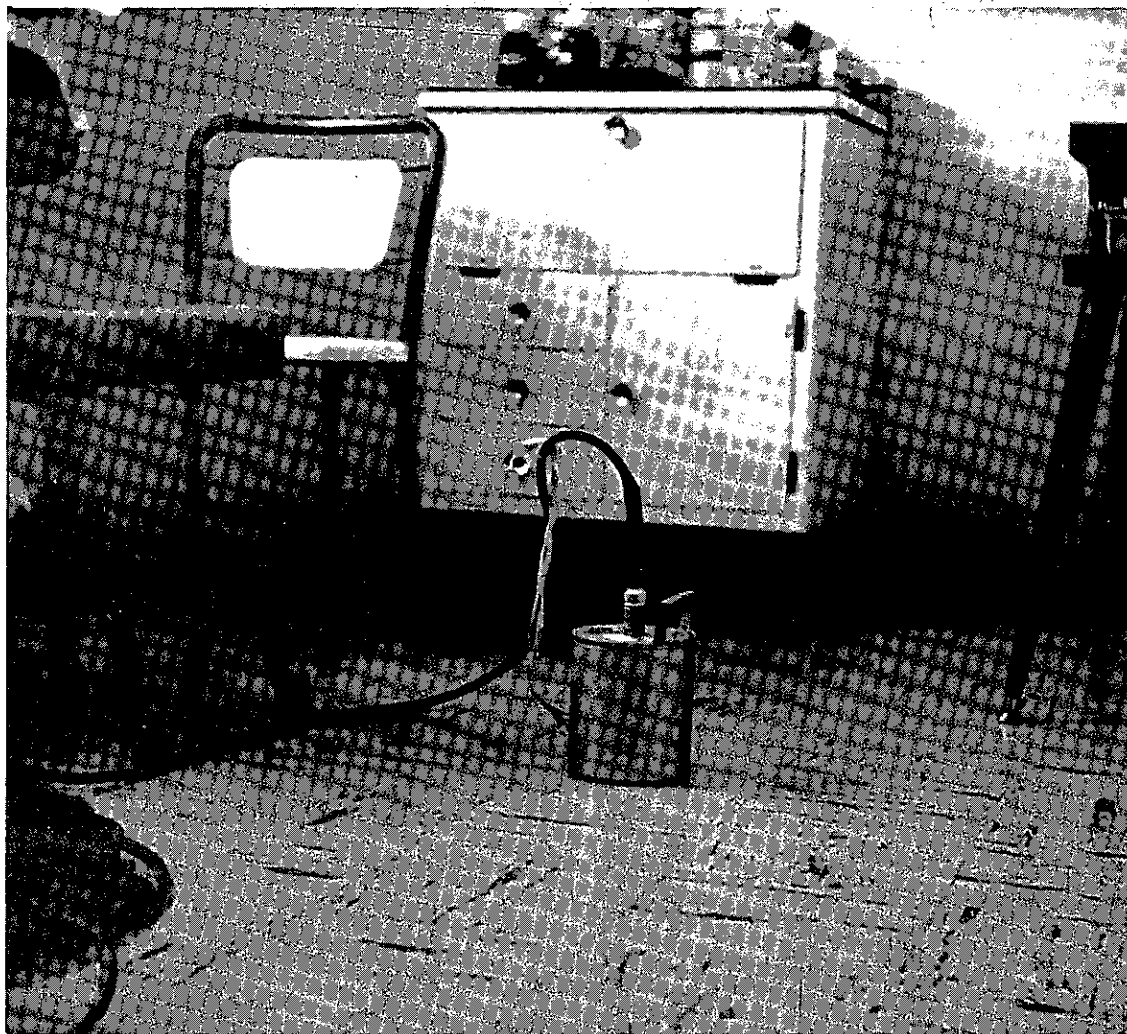


FIGURE 5

Seismometer on the floor of
Dr. Covey's Room 1.

Figure 6

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-I34644

Vibration Test Record

No. 5

Date: Aug. 22, 1967

Channel 3 Location: Dr. Covey - Rm. 1

Channel 4 Location: Bridge Deck

Vibration Source: Fill Haul Truck - Loaded

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

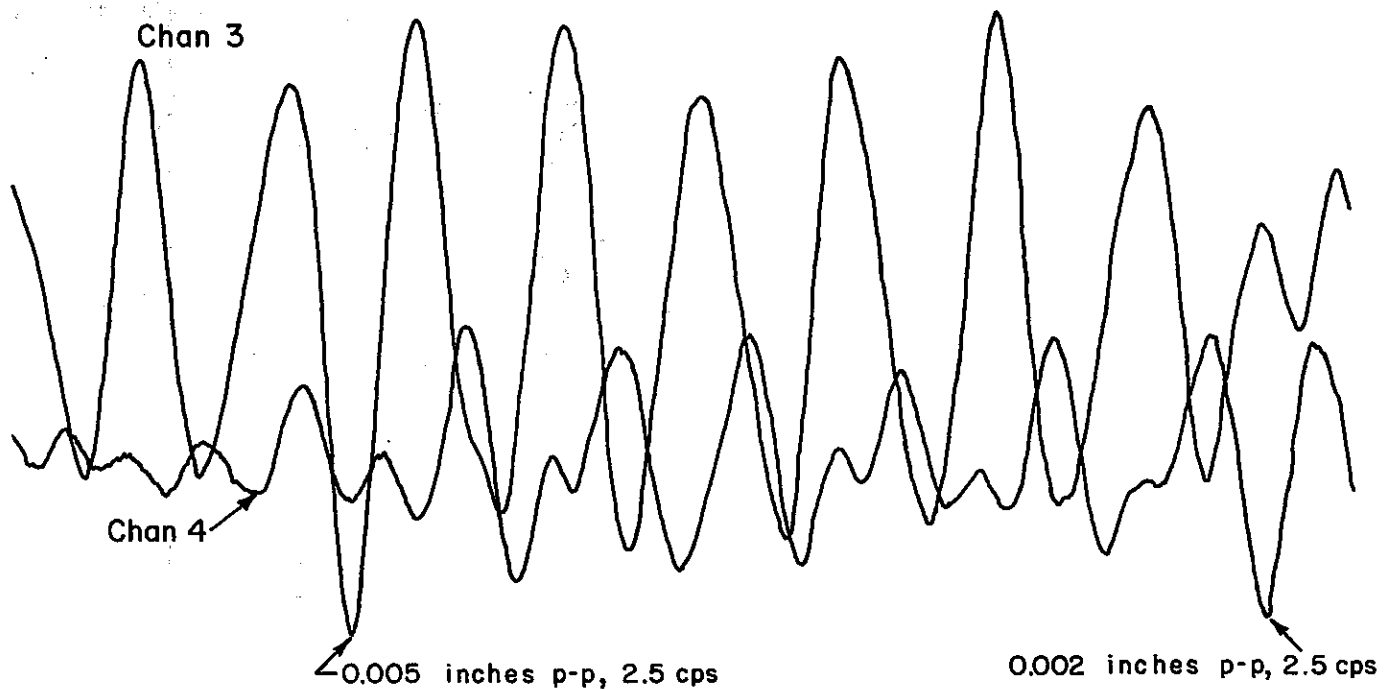




FIGURE 7

Seismometer on the floor of
Dr. Covey's Room 3.



FIGURE 8

Seismometer on the floor of
Dr. Holtzman's Room 4.

Figure 9

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record

No. 7

Date: Aug. 22, 1967

Channel 3 Location: Dr. Covey - Rm. 2

Channel 4 Location: Bridge Deck

Vibration Source: Fill Haul Truck - Loaded

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

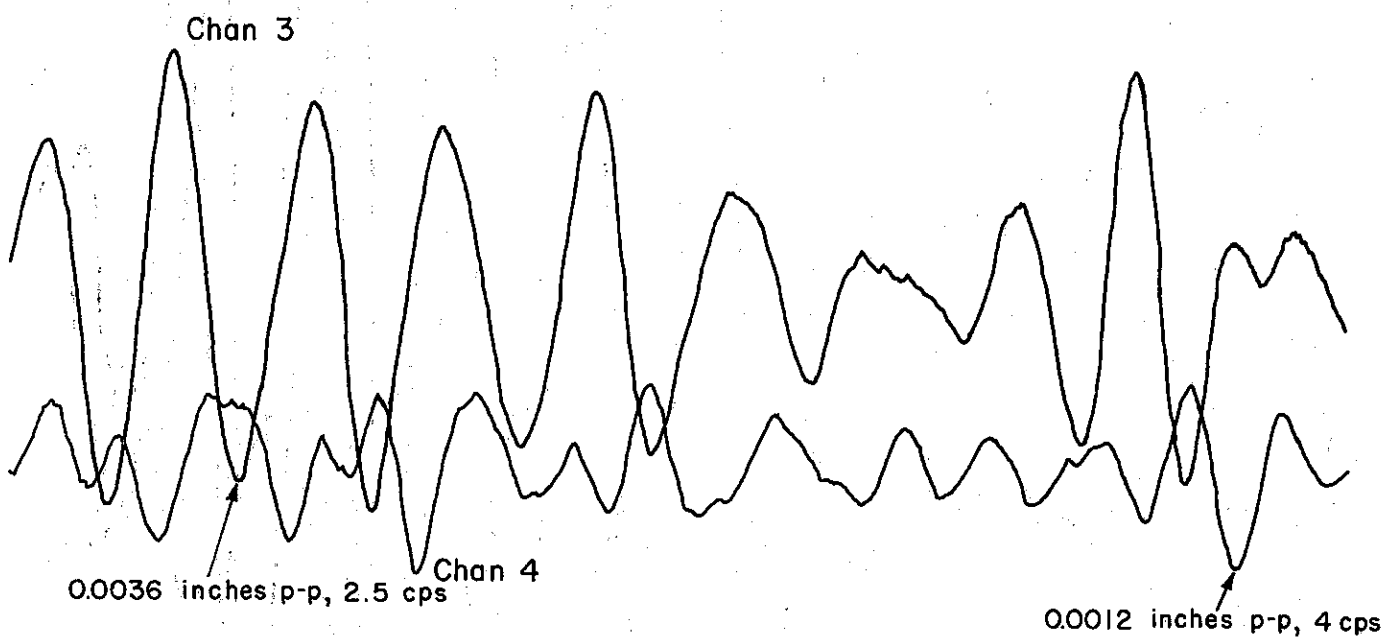


Figure 10

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record

No. 13

Date: Aug. 22, 1967

Channel 3 Location: Dr. Covey - Room 3

Channel 4 Location: Bridge Deck

Vibration Source: Two Fill Haul Trucks - Loaded

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

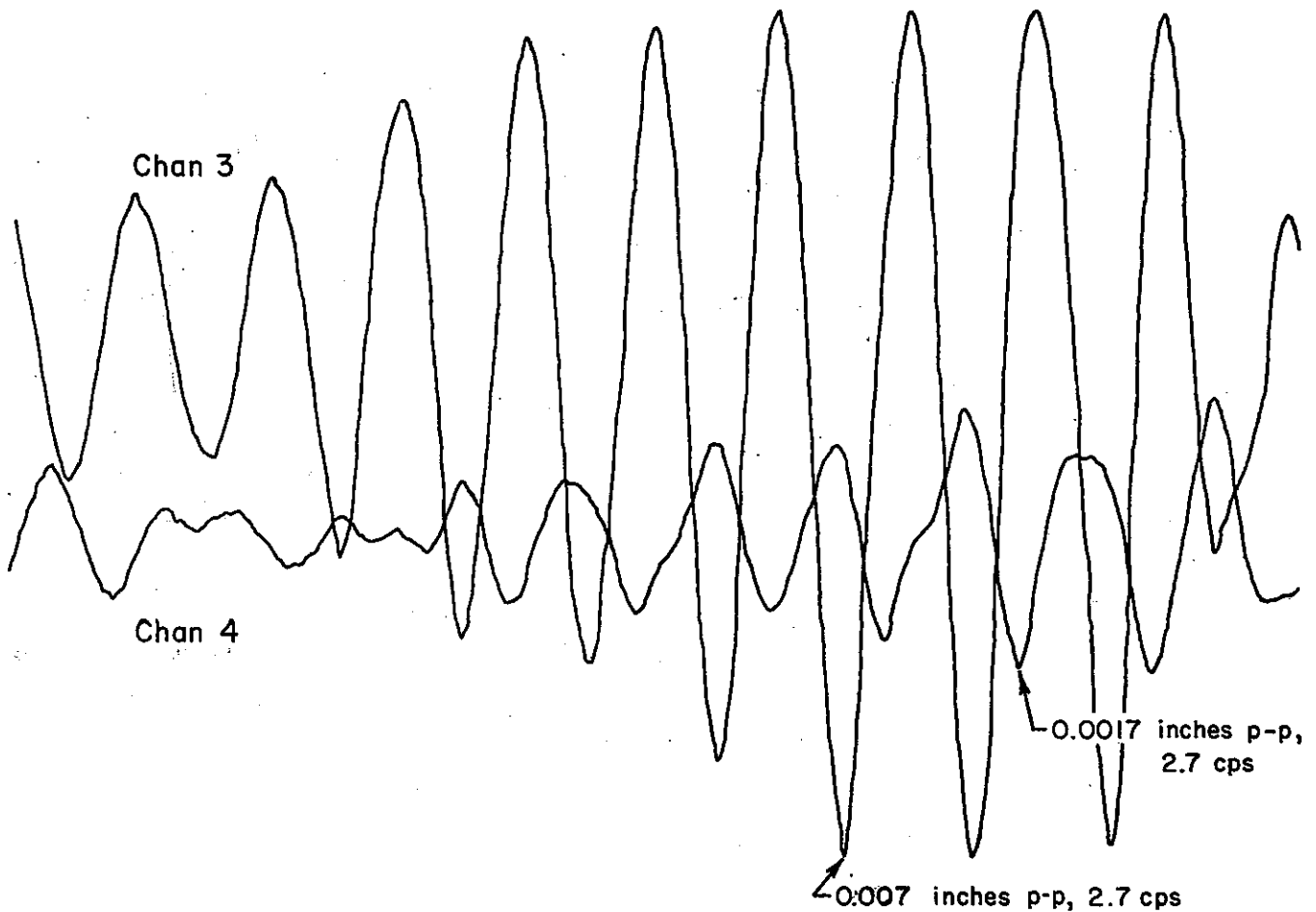


Figure II

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record

No. 17

Date: Aug 22, 1967

Channel 3 Location: Dr. Holtzman - Rm. 4

Channel 4 Location: Bridge Deck

Vibration Source: Loaded Truck Going Up Bridge, Empty Truck Going
Chart Speed: 2 inches per second. Down Bridge.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

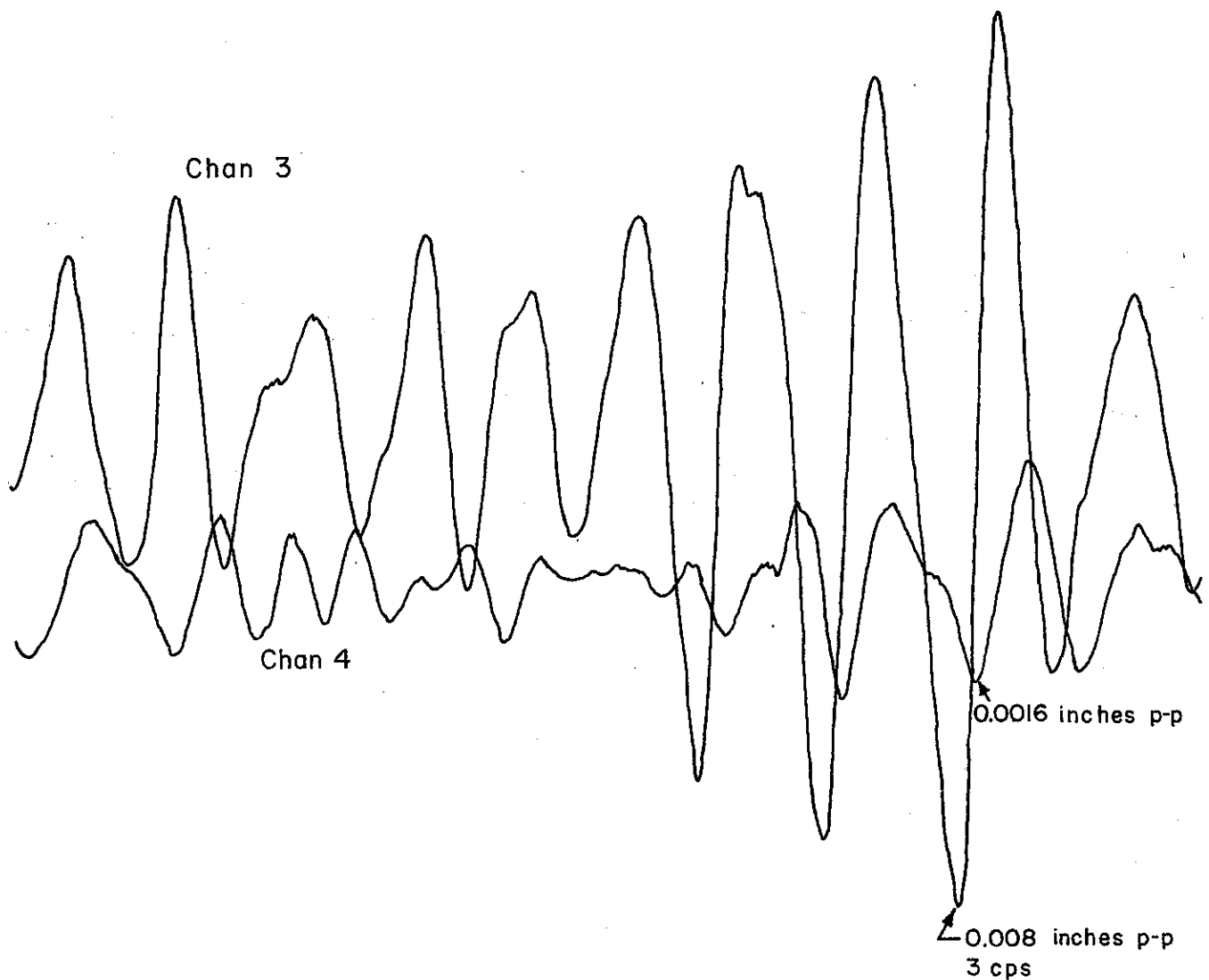


Figure 12

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record No. 16 Date: Aug 22, 1967

Channel 3 Location: Dr. Holtzman - Rm 4

Channel 4 Location: Bridge Deck

Vibration Source: Quiet Period - No Disturbance

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

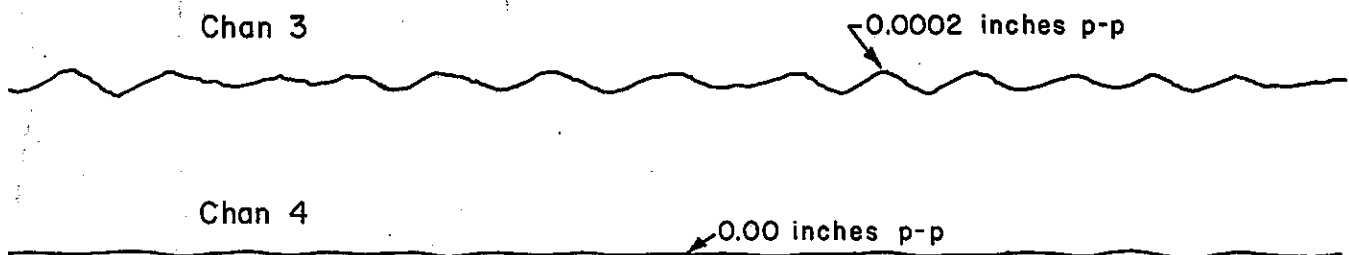


Figure 13

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record

No. 30

Date: Aug. 22, 1967

Channel 3 Location: \bigcirc^8 , See Fig. 1, Secretary's Office

Channel 4 Location: \bullet^6 , See Fig. 1

Vibration Source: Fill Haul Truck - Loaded

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

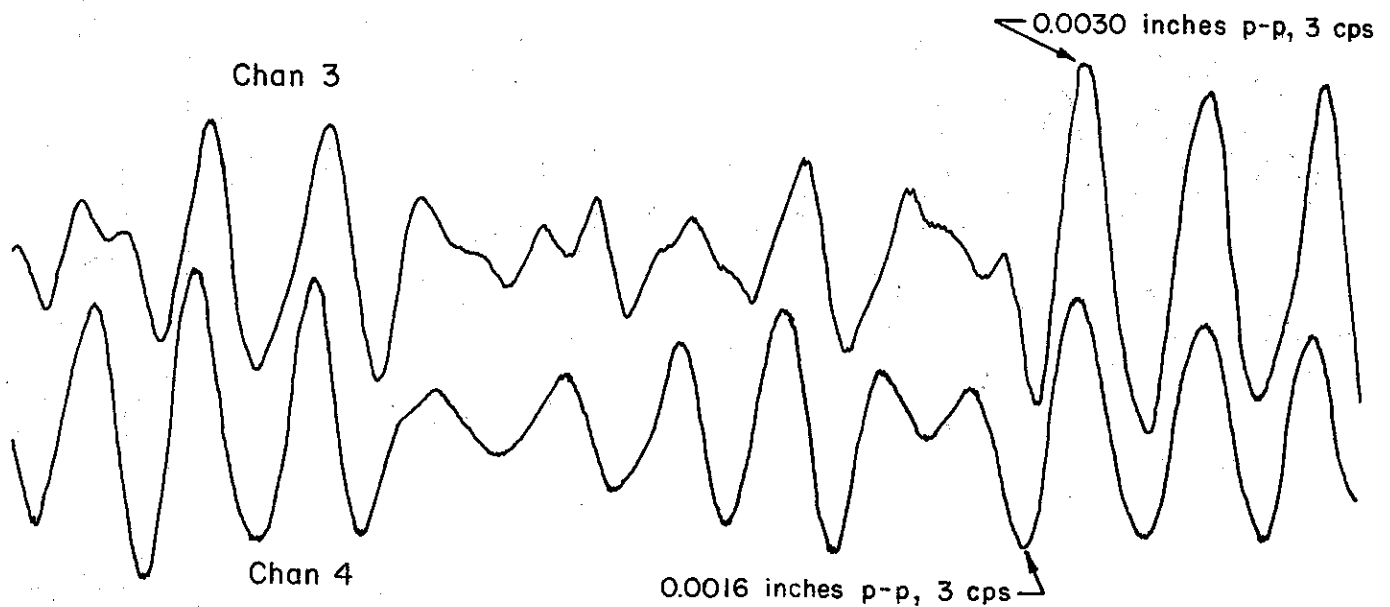


Figure 14

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record

No. 33

Date: Aug. 22, 1967

Channel 3 Location: \bigcirc^7 , See Fig. 1, Grant's Office

Channel 4 Location: \bullet^6 , See Fig. 1

Vibration Source: Fill Haul Truck - Loaded

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

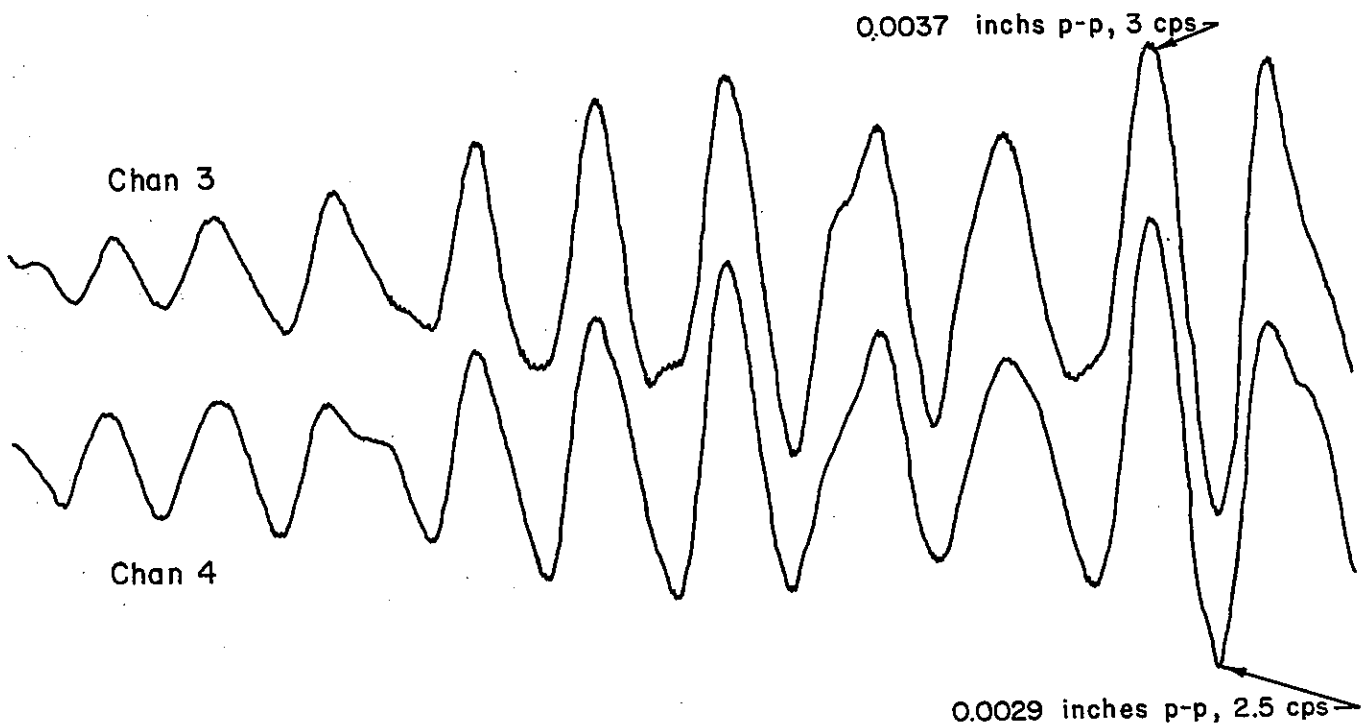


Figure 15

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record No. 31 Date: August 22, 1967

Channel 3 Location: ○⁹, See Fig. 1, Grant's conference room

Channel 4 Location: ●⁶, See Fig. 1,

Vibration Source: Fill Haul Truck - Loaded

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

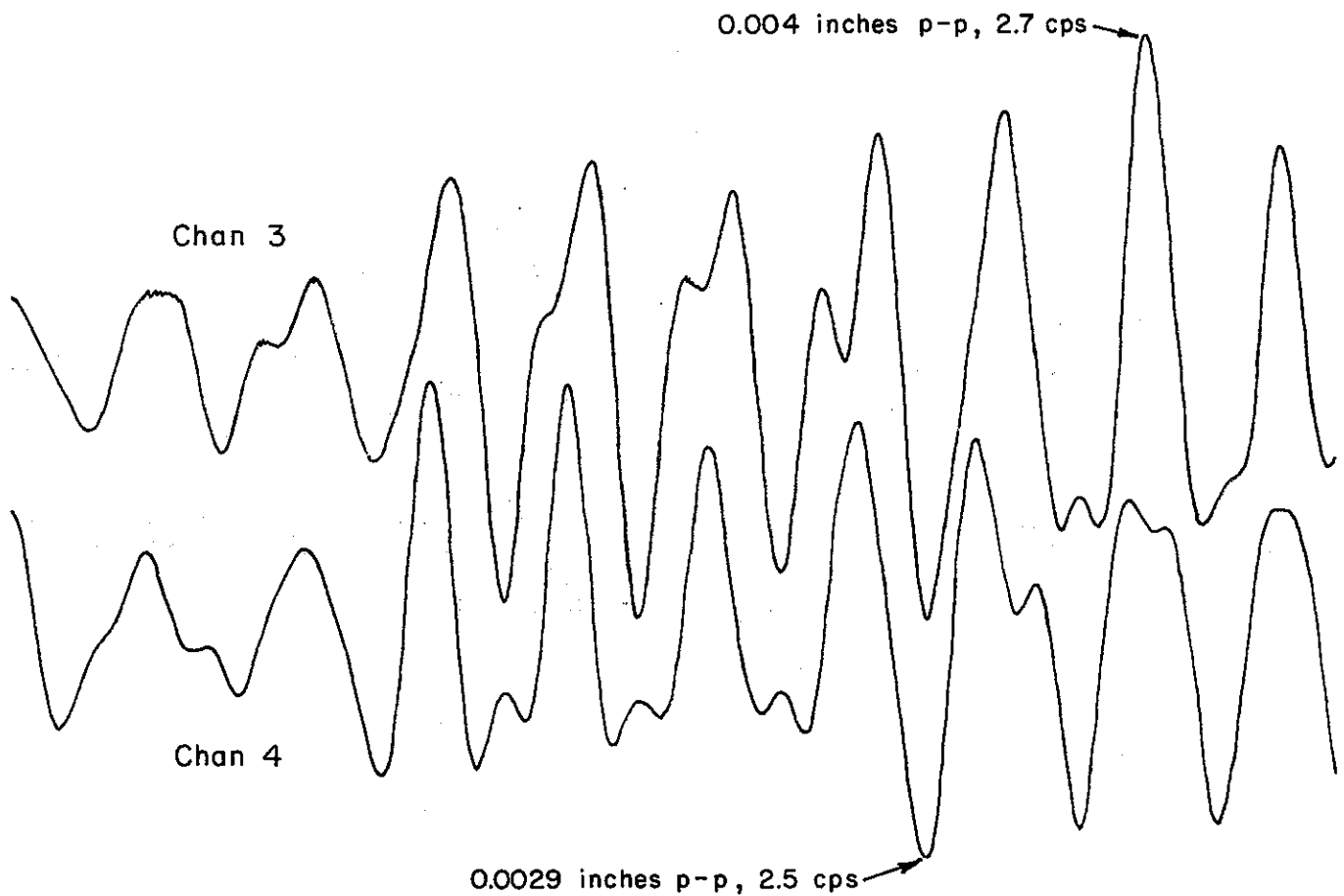


Figure 16

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record

No. 25

Date: Aug. 22, 1967

Channel 3 Location: \bigcirc^8 , See Fig. 1, Secretary's Office

Channel 4 Location: \bullet^6 , See Fig. 1,

Vibration Source: Quiet Period, No Disturbance

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

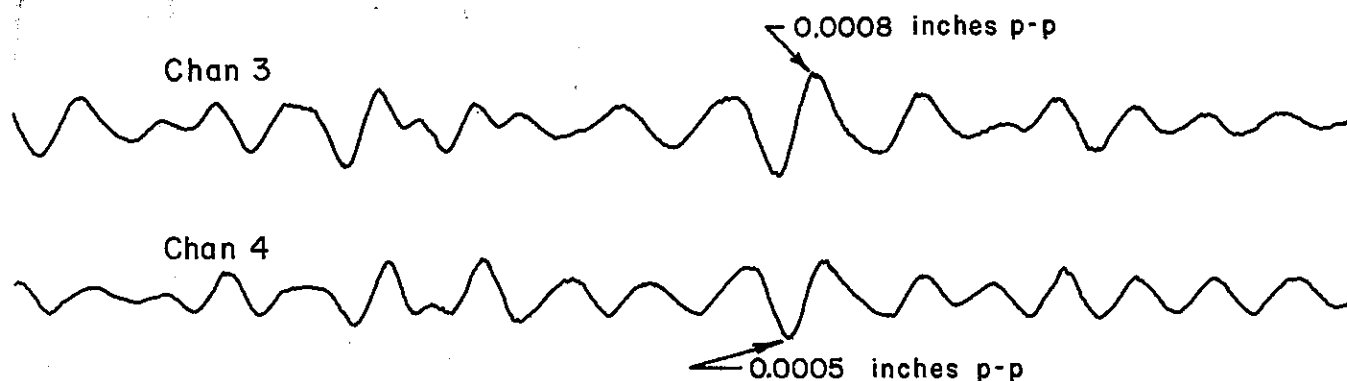


Figure 17

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record

No. 11

Date: Aug. 22, 1967

Channel 3 Location: Dr. Covey - Rm. 2

Channel 4 Location: Bridge Deck

Vibration Source: Nurse Walking in Dr. Covey's Rm. 2

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

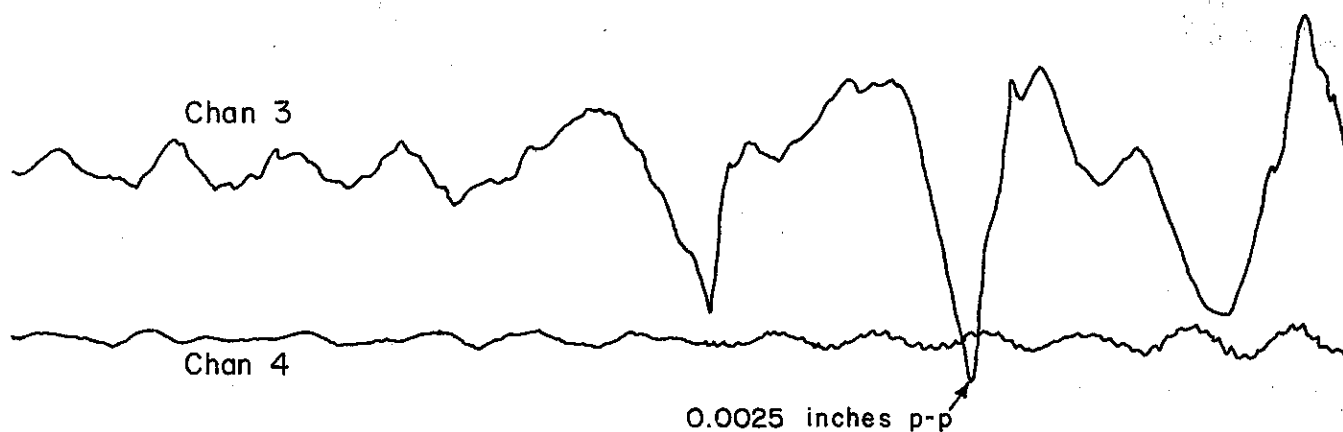


Figure 18

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record

No. 15

Date: Aug. 22, 1967

Channel 3 Location: Dr. Holtzman - Rm. 4

Channel 4 Location: Bridge Deck

Vibration Source: Walking in Rm. 4

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

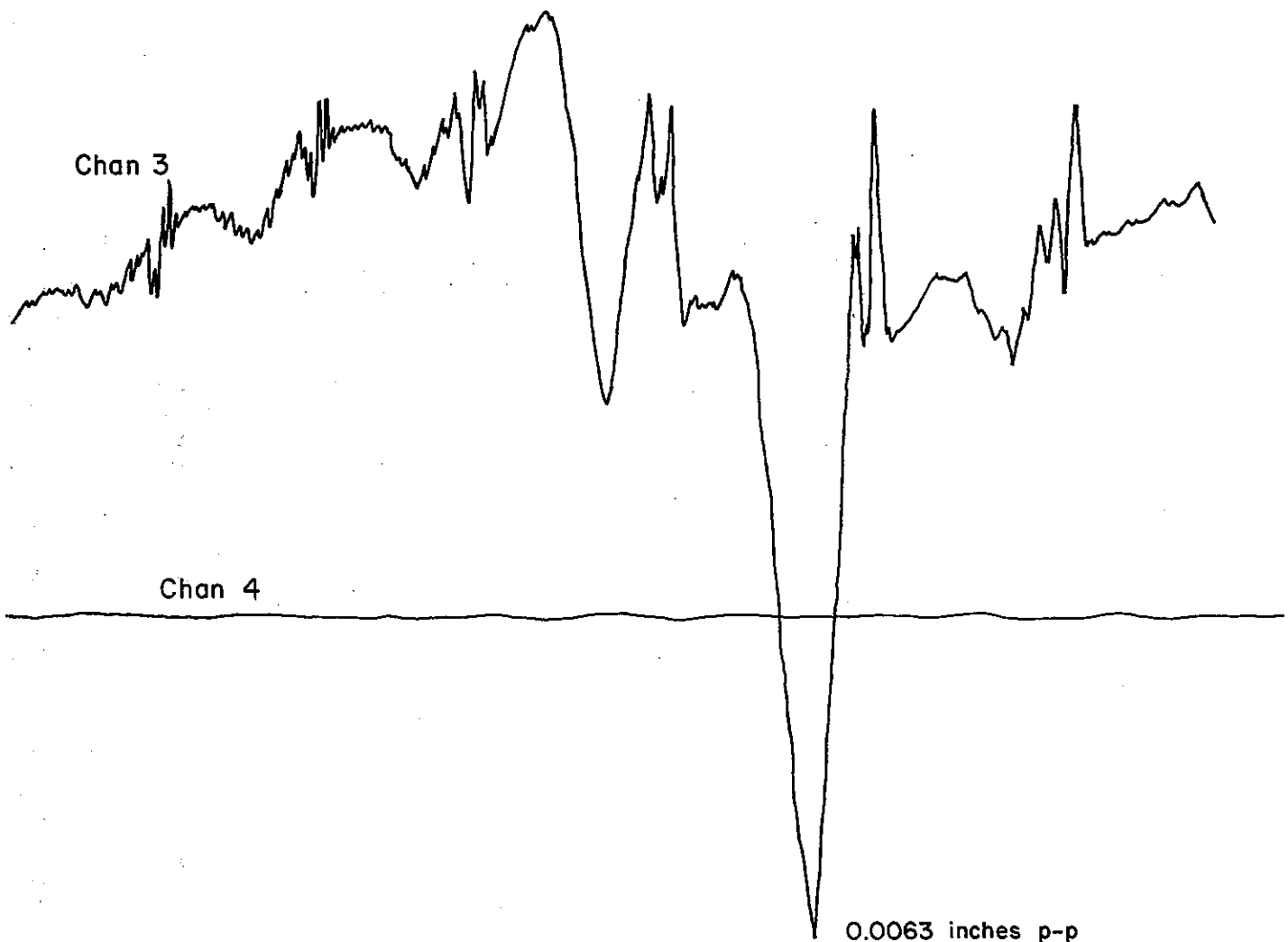


Figure 19

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record No. 29 Date: Aug. 22, 1967

Channel 3 Location: O⁸, See Fig. 1, Secretary's Office

Channel 4 Location: ●⁶, See Fig. 1

Vibration Source: Walking Around Secretary's Desk

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

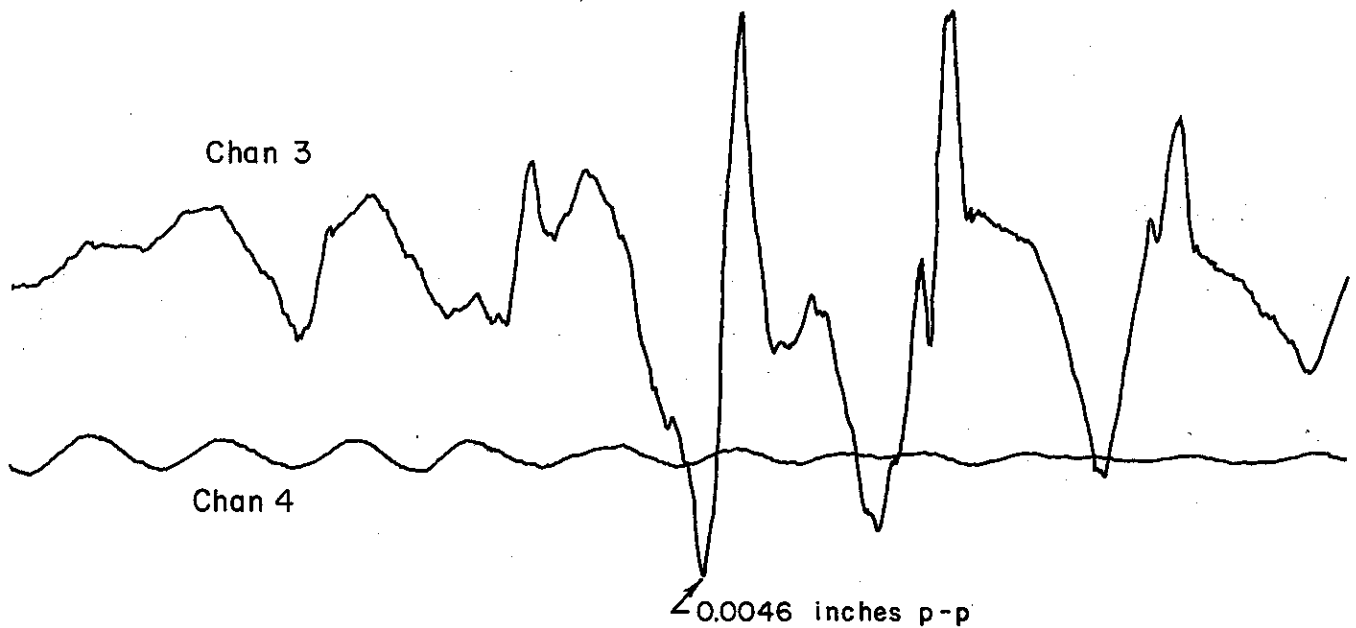


Figure 20

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record

No. 32

Date: Aug. 22, 1967

Channel 3 Location: ○⁷, See Fig. 1, Grant's Office

Channel 4 Location: ●⁶, See Fig. 1

Vibration Source: Walking in Conference Room

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

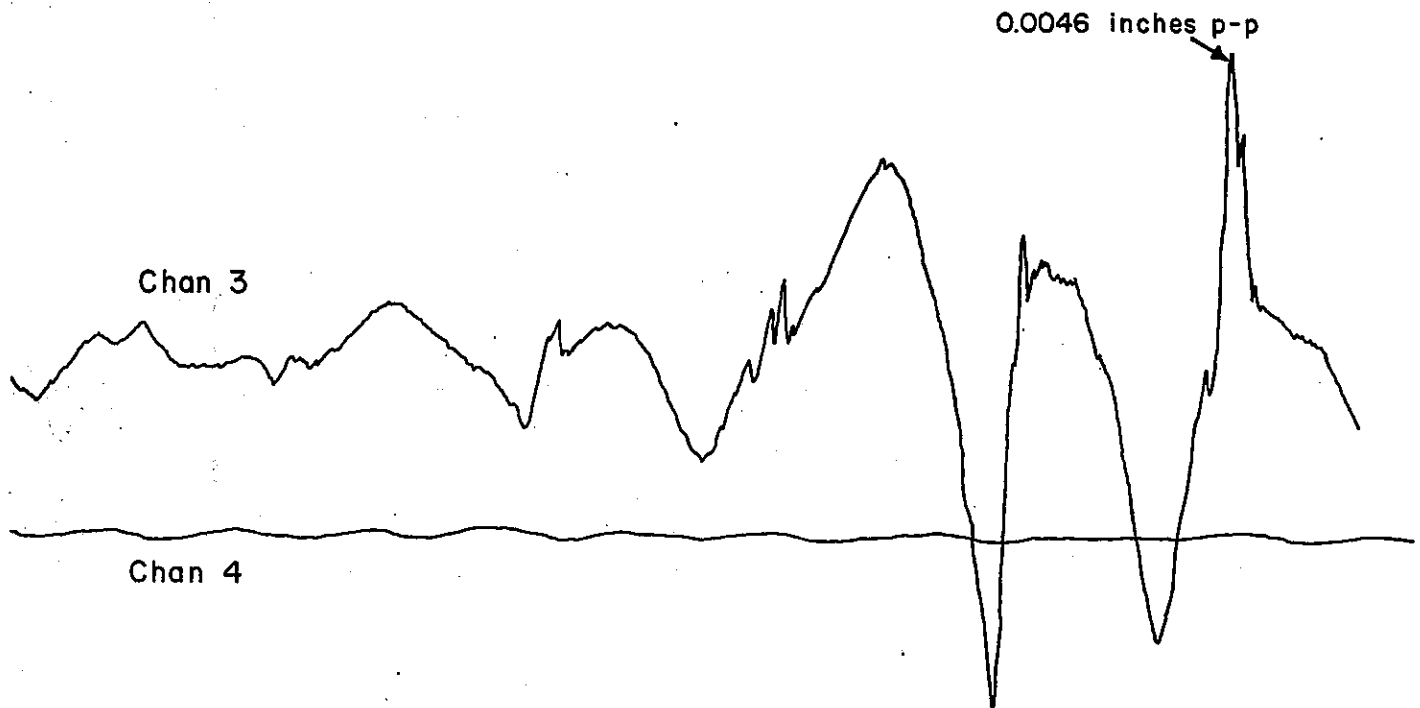


Figure 21

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record

No. 18

Date: Aug. 22, 1967

Channel 3 Location: 17 Ft. from Truck Wheel Path, O_{11}^{II}

Channel 4 Location: 77 Ft. from Truck Wheel Path, O_{10}^{II}

Vibration Source: Fill Haul Truck - Loaded

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

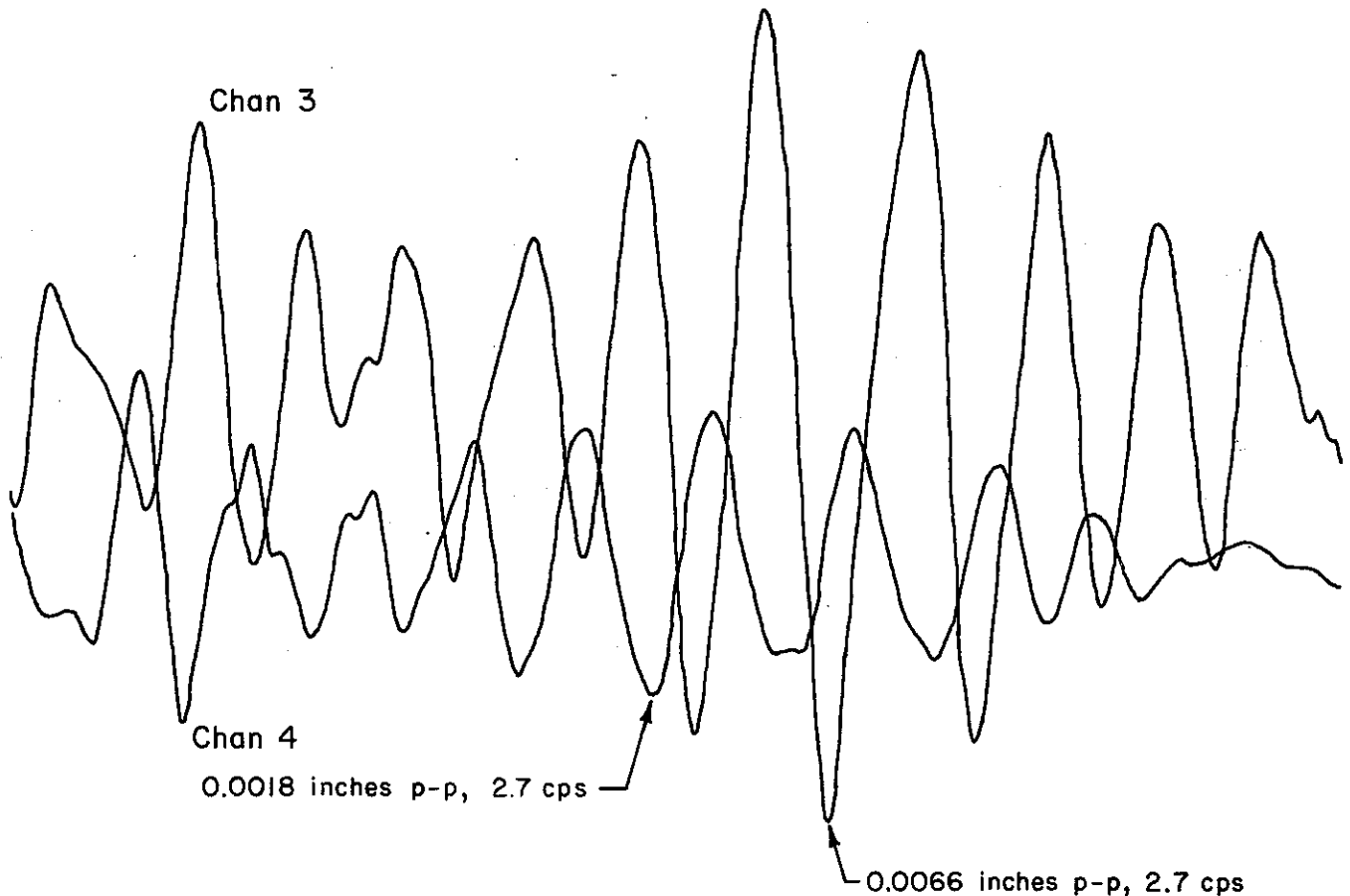


Figure 22

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record

No. 34

Date: Aug. 22, 1967

Channel 3 Location: \bigcirc^{13} , See Fig. 1

Channel 4 Location: \bullet^{12} , See Fig. 1

Vibration Source: Fill Haul Truck on 19th Ave.

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

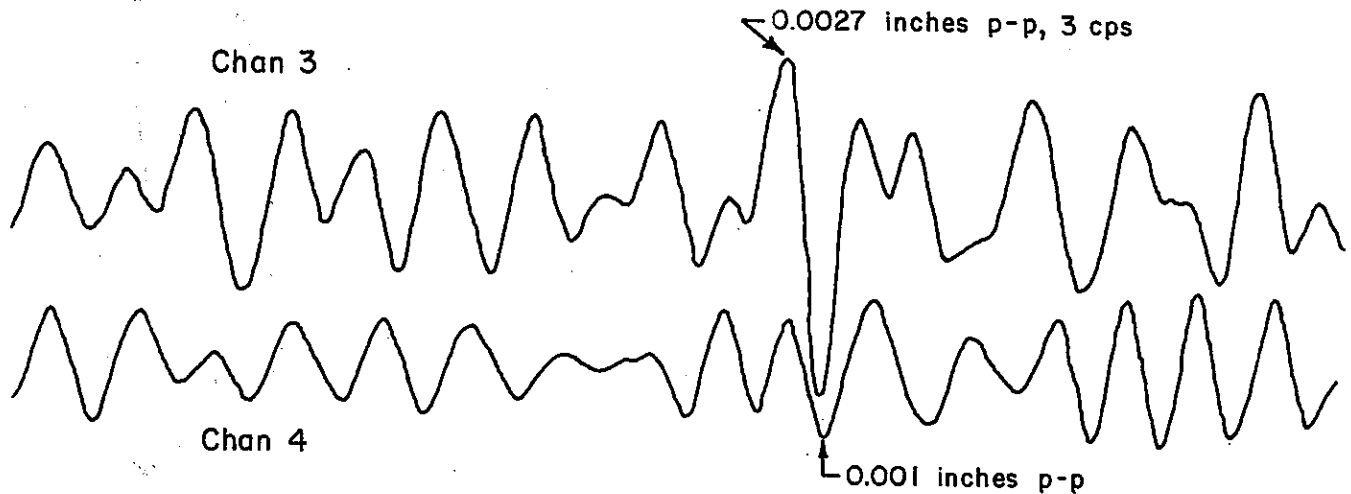


Figure 23

PARKSIDE MEDICAL-DENTAL BLDG.

VIBRATION SURVEY

ROAD 04-SM-92 12.2/14.3X CONTRACT 04-134644

Vibration Test Record

No. 24

Date: Aug. 22, 1967

Channel 3 Location: O¹¹, See Fig. 1

Channel 4 Location: O¹⁰, See Fig. 1

Vibration Source: Car Traffic on Norfolk Street

Chart Speed: 2 inches per second.

Vibration Scale: Chan. 3 - 0.0015 in/in.

Chan. 4 - 0.0012 in/in.

p-p: Peak to Peak

cps: Cycles per Second

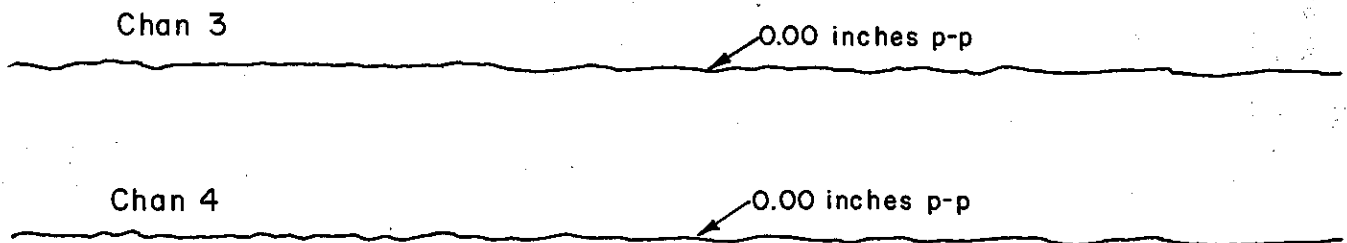
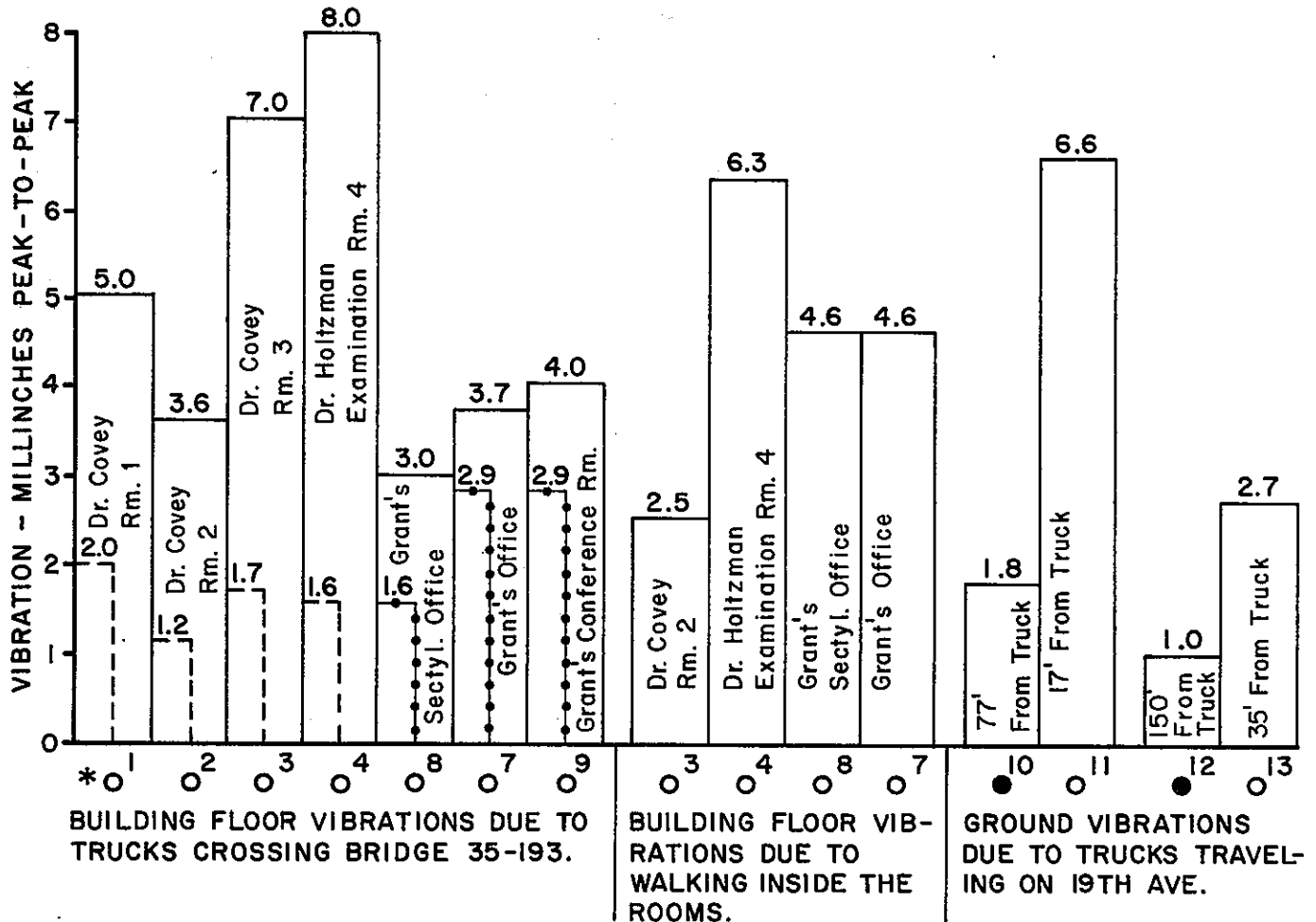


Figure 24

PARKSIDE MEDICAL-DENTAL BUILDING VIBRATION SURVEY

ROAD 04-SM-92 12.2 / 14.3X

GRAPH OF MAXIMUM VIBRATIONS MEASURED AT INDICATED LOCATIONS



*For exact location see Figure 1.

----- Indicates simultaneous vibration on bridge deck location \odot^5

---•--- Indicates simultaneous vibration on ground location \odot^6

